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Riggs

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(54) **SEED TREATMENT FUNGICIDES FOR CONTROL OF PLANT DISEASES**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**⁷ **A01N 37/34**; A01N 47/10

(52) **U.S. Cl.** **514/479**; 514/478; 514/491; 514/528

(58) **Field of Search** 514/528, 491, 514/478, 479

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(57) **ABSTRACT**

A method for combatting plant fungi in a plant, which comprises applying to the seeds or tubers of the plant, an effective amount of a fungicidal composition comprising a fungicidally effective amount of a 2-alkoxyiminoacetamide compound, optionally in admixture with one or both of an alkylene bis-dithiocarbamate complex salt and a thiophanate compound. Fungicidal compositions comprising a fungicidally effective amount of a 2-alkoxyiminoacetamide compound, an alkylene bis-dithiocarbamate complex salt, and a thiophanate compound, are also described.

22 Claims, No Drawings

The method and composition of this invention are particularly suitable for use against *Phytophthora infestans* on or in potato plants and tubers.

The composition of this invention and the compounds useful in the method of this invention can be formulated in conventional ways. Examples of useful formulations include slurries, solid seed coatings, soaks, dusts on the surface of the seed or tuber, solutions, suspensions, emulsions, wettable powders, emulsifiable concentrates, and the like. The formulations, in general, comprise about 1% to 99% by weight of active ingredient. The formulations can additionally comprise additional additives such as surfactants, solid or liquid diluents, pigments, thickeners, and the like. The method of application of the formulations to the seeds or tubers can vary depending, e.g., on the compounds and/or the formulation used.

In general, the seed or tuber should be treated with about 50 to about 1200 ppm, preferably between about 300 to about 900 ppm, most preferably, about 700 ppm, per 100 pounds ("cwt") of seed or tuber, of the composition of this invention or of the compounds useful in the method of this invention.

This invention preferably relates to a method for combating plant fungi in a plant, which comprises applying to the seeds or tubers of the plant, an effective amount of a fungicidal composition comprising a fungicidally effective amount of:

- a) cymoxanil; or
- b) cymoxanil in admixture with one or more of the group consisting of mancozeb and thiophanate-methyl.

This invention further preferably relates to a fungicidal composition comprising cymoxanil, mancozeb and thiophanate-methyl, in an effective aggregate amount.

Cymoxanil, mancozeb and thiophanate-methyl are all known compounds.

Cymoxanil (a foliar fungicide sold under the trademarks CURZATE and DPX-3217) is 2-cyano-N-[(ethylamino)carbonyl]-2-(methoxyimino)-acetamide.

Mancozeb (a fungicide sold under the trademarks MANZATE-200 and DITHANE M-45) is a mixture of [[1,2-ethanediybis-(carbamodithioato)](2-)]manganese and [[1,2-ethanediybis(carbamothioato)](2-)]zinc.

Thiophanate-methyl (a systemic fungicide sold under the trademarks TOPSIN M and NF-44) is dimethyl[1,2-phenylene-bis-(iminocarbonyl-thioyl)-bis-[carbamate]].

In the method of this invention wherein cymoxanil is admixed with thiophanate-methyl, in general, satisfactory results can be obtained when the weight ratio of cymoxanil:thiophanate-methyl is from about 1:3 to 3:1, preferably 1:2 to 2:1, and more preferably, 1:1.5 to 1.5:1.

In the method of this invention wherein cymoxanil is admixed with mancozeb, in general, satisfactory results can be obtained when the weight ratio of cymoxanil:mancozeb is from about 1:16 to 3:1, preferably 1:8 to 2:1, and more preferably, 1:3 to 1.5:1.

In the method of this invention wherein cymoxanil, mancozeb and thiophanate-methyl are admixed, in general, satisfactory results can be obtained when the weight ratio of cymoxanil:mancozeb:thiophanate-methyl is from about 3:1:1 to about 1:16:6, preferably, about 1.5:1:1 to about 1:8:3.

Similarly, in the composition of this, invention, in general, satisfactory results can be obtained when the weight ratio of cymoxanil:mancozeb:thiophanate-methyl is from about 3:1:1 to about 1:16:6, preferably, about 1.5:1:1 to about 1:8:3.

The formulations can comprise from 0 to about 20% of an agriculturally acceptable surfactant such as wetting and dispersing agents, e.g., the condensation product of formaldehyde with naphthalene sulphonate, an alkylarylsulphonate, a lignin sulphonate, a fatty sulphate, an ethoxylated alkylphenol and an ethoxylated fatty alcohol. The formulations can additionally comprise from about 10 to about 99% of an agriculturally acceptable solid or liquid diluent, including carriers, such as talc, zeolites, Alder bark, kaolin, diatomaceous earth, mineral oil, water, and the like.

The following examples are provided to illustrate the present invention.

EXAMPLES

Example 1

(A) A potato dust inert system (PDIS) was prepared by blending the following three inert diluents in a ribbon blender: talc (Cyprus BT-200)(48.39% w/w), zeolite (16.12% w/w), and Alder bark (35.49% w/w).

The dusts listed in Table 1 below were prepared by blending PDIS and the compounds at the concentrations indicated in a ribbon blender and were evaluated for activity against *P. infestans* at the rate of application of active ingredient indicated.

TABLE 1

Dust No.	Compound	Percent (w/w)	Percent PDIS (w/w)	Rate of Application (ppm/cwt ¹)
1	Cymoxanil	10.5	89.5	500
2	Cymoxanil	5.3	91.5	250
	Topsin ²	3.2		150
3	Dimethomorph ³	10.5	89.5	500
4	Dimethomorph	5.3	91.5	250
	Topsin	3.2		150
5	Propamocarb ⁴	10.5	89.5	500
6	Propamocarb	5.3	91.5	250
	Topsin	3.2		150
7	Topsin	5.3	94.7	250
8	Topsin	2.6	89.9	250
	Mancozeb	7.5		600

¹parts per million per hundred lbs. of seed (tuber)

²thiophanate-methyl

³(E,Z) 4-[3-(4-chlorophenyl)-3-(3,4-dimethoxyphenyl)acryloyl]morpholine

⁴Propyl[3-(dimethylamino)propyl]carbamate

(B) The in-vitro screening procedure was conducted as follows:

Potato tubers were removed from 5° C. storage and allowed to come to room temperature. The tubers were then washed with tap water and sterilized in 5% commercial bleach (Clorox) for 10 minutes. The tubers were then rinsed in sterile distilled water and dried.

Phytophthora infestans was grown on agar plates at 18° C. for 10–14 days. 20 ml. of 5° C. sterile distilled water were then added to each plate. The agar was then agitated or cut into smaller sections and placed at 10–12° C. for 2 hours to release zoospores.

Tubers were cut into uniform sized slices (1 cm thick). Each dust was applied to 20 slices at 0.5 lb/cwt. Two sets of 20 potato slices were left untreated with dust and used as controls. Each dusted potato slice was then placed on sterile moistened filter paper in a sterile petri dish.

A zoospore suspension was quantified to a concentration of 20,000 spores/ml. 100 ul of this spore suspension was then applied to a sterile filter paper disk. One such treated disk was placed in the center of each potato slice. One set of 20 undusted potato slices were not inoculated and used as a sterile control.

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Each potato slice was then placed in the dark at 18° C. for 7 days. After the 7 days, the disease state of each potato slice was assessed.

In Table 2 below, growth and sporulation of *P. infestans* for each potato slice was rated on a plus (+) or minus (-) scale. A minus indicates no growth of the *P. infestans* whereas a plus indicates growth. Growth was measured as minimal (+), good (++) , or good and sporulation (+++).

TABLE 2

GROWTH AND SPORULATION OF <i>P. INFESTANS</i>	
Dust No.	Growth
1	-
2	-
3	-
4	-
5	+++
6	++
7	+
8	-
Untreated	+++
Sterile	-

Example 2

(A) Dusts were prepared as described in Example 1 above.

(B) The in-vivo screening procedure was conducted as follows:

Potato tubers were removed from 5° C. storage and allowed to come to room temperature. The tubers were then washed with tap water and sterilized in 5% commercial bleach (Clorox) for 10 minutes. The tubers were then rinsed in sterile distilled water and dried.

Phytophthora infestans was grown on agar plates at 18° C. for 10–14 days. 20 ml. of 50° C. sterile distilled water were then added to each plate. The agar was then agitated or cut into smaller sections and placed at 10–12° C. for 2 hours to release zoospores. A zoospore suspension was quantified to a concentration of 20,000 spores/ml.

Small punctures were made in the tubers with a sterile needle and the punctured tubers were then dipped into the suspension of *P. infestans* zoospores. The tubers were then incubated at 15° C. with 95% relative humidity for 7–10 days. After the incubation the tubers were then cut into 2–4 oz. pieces. Each dust was applied to 15 pieces at 0.5 lb/cwt or according to manufacturer's directions. One set of 15 pieces was left untreated and used as a control.

Potatoes not dipped in the zoospores were also cut into 2–4 oz. pieces and one set of 15 uniaoculated potato pieces was used as a sterile control.

The potato pieces were then placed in sandy soil and incubated at 17° C. days and 13° C. nights for 32 days. Growth after emergence was monitored for 14–28 days. Disease symptoms were visually rated. Stem/leaf tissue was assayed for *P. infestans* on appropriate media. Finally, potato seed pieces were then removed and cut in half and disease presence was visually assessed.

The results of this test are presented below in Tables 3 and 4.

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TABLE 3

Germination and Emergence Results		
Dust No.	Emergence (%) Day 14	Germination (%) Day 32
1	33.3	100
2	33.3	100
3	26.7	80
4	33.3	53.3
6	20	40
8	6.7	6.7
Untreated	20	13.3
Sterile	33.3	100

TABLE 4

TUBER AND STEM HEALTH				
Dust No.	A ¹ (%)	B ² (%)	C ³ (%)	D ⁴ (%)
1	0	0	26.7	73.3
2	0	0	0	100
3	20	26.7	53.3	0
4	40	13.3	40	0
6	60	20	20	0
8	93.3	6.7	0	0
Untreated	86.7	13.3	0	0
Sterile	0	0	0	100

¹Blighted tuber; No emergence

²Blighted tuber; Small-sized infected stems

³Blighted tuber; Average-sized infected stems

⁴Clean tubers; Healthy uninfected stems

Example 3

The following new dusts in Table 5 were prepared as described in Example 1.

TABLE 5

Dust No.	Compound	Percent (w/w)	Percent PDIS (w/w)	Rate of Application (ppm/cwt)
9	Cymoxanil	5.3	94.7	250
10	Cymoxanil	2.1	94.7	100
11	Topsin ²	3.2		150
11	Cymoxanil	4.2	92.6	200
11	Topsin	3.2		150
12	Cymoxanil	2.1	92.2	100
12	Mancozeb	2.5		100
12	Topsin	3.2		150
13	Topsin	5.2	87.3	500
13	Mancozeb	7.5		600

These dusts were tested using the procedure described in Example 2 above. The results of this testing is shown in Table 6 below.

TABLE 6

EMERGENCE AND TUBER AND STEM HEALTH					
Dust No.	Emergence (%)			Infection (%)	
	Day 15	Day 23	Day 35	Tubers	Stems
9	0	20	80	20	0
10	0	0	60	40	33.3
11	0	20	100	40	33.3
12	20	80	100	0	0

TABLE 6-continued

EMERGENCE AND TUBER AND STEM HEALTH					
Dust No.	Emergence (%)			Infection (%)	
	Day 15	Day 23	Day 35	Tubers	Stems
13	0	0	0	100	no stems
Untreated	0	0	0	100	no stems
Sterile	0	100	100	0	0

Example 4

The following dusts in Table 7 were prepared as described in Example 1.

TABLE 7

Dust No.	Compound	Percent (w/w)	Percent PDIS (w/w)	Rate of Application (ppm/cwt)
14	Mancozeb (80%)	10.0	90.0	400
15	Cymoxanil (96%)	2.1	97.9	100
16	Cymoxanil (96%)	2.1	90.9	100
	Mancozeb (80%)	7.5		300
17	Topsin (95%)	3.2	92.8	150
	Cymoxanil (50%)	4.0		100
18	Topsin (95%)	3.2	84.7	150
	Mancozeb (80%)	10.0		400
	Cymoxanil (96%)	2.1		100
19	Topsin (95%)	3.2	87.3	150
	Mancozeb (80%)	7.5		300
	Cymoxanil (96%)	2.1		100

These dusts (as well as Dust Nos. 7 and 8) were tested using the procedure described in Example 2 above using Russet Burbank tubers. The results of this testing (10 replications/treatment) are shown in Table 8 below.

TABLE 8

EMERGENCE AND STEM HEALTH			
Dust No.	Emergence (%)		Infection (%)
	Day 14	Day 28	Stems
7	0	0	no stems
8	10	10	100
14	0	10	100
15	30	40	25
16	20	40	0
17	10	30	33
18	30	40	0
Untreated	0	0	no stems
Sterile	60	100	0

Example 5

The dusts prepared in Example 4 above (as well as Dust Nos. 7 and 8) were tested using the procedure described in Example 2 above using Red Nordland tubers. The results of this testing (7 replications/treatment) are shown in Table 9 below.

TABLE 9

EMERGENCE AND STEM HEALTH			
Dust No.	Emergence (%)		Infection (%)
	Day 10	Day 38	Stems
7	0	0	no stems
8	14.3	14.3	100
14	0	0	no stems
15	85.7	100	14
16	57.1	85.7	0
17	42.9	85.7	14
18	71.4	100	0
Untreated	0	0	no stems
Sterile	57.1	100	0

Example 6

Shepody potato tubers were contaminated/inoculated with *Phytophthora infestans* and set aside ("source tubers"). After two weeks, one (1) source tuber was cut into quarters through the diseased area with a cutting knife. Without cleaning or changing the knife, five (5) uninoculated Shepody potato tubers were then cut into quarters. This process (1 source tuber/5 uninfected tubers) was repeated to provide enough tubers for 30 replications per treatment (Table 10 below).

The cut tubers (source and uninoculated) were weighed and the appropriate amount of each dust listed in Table 10 below was applied to the tubers by placing the tubers in a double paper bag with dust and then shaking the bag.

The treated tubers were then placed in an unsealed plastic bag (one bag per treatment) and incubated at 10° C., 80–90% RH, for two (2) weeks. After two (2) weeks, the bagged tubers were removed from the 10° C., 80–90% RH environment. The bags were then rolled or shaken to simulate movement from storage to planting areas. The tubers were removed and the spread of *P. infestans* was determined—% infected tubers. The tubers were warmed to room temperature and planted. The source tubers were not planted. Emergence and infection data were obtained as described above in Example 2 (30 replications/treatment).

The results of this test are listed below in Table 10.

TABLE 10

EMERGENCE AND TUBER AND STEM HEALTH				
Dust No.	Emergence (%)		Infection (%)	
	Day 6	Day 20	Tubers (Before planting)	Stems
7	20	86.7	60	40
8	26.7	80	40	20
14	20	83.3	20	10
15	30	100	20	0
17	40	93.3	40	0
18	56.7	100	30	0
19	20	100	30	0
Untreated	16.7	70	90	40

Example 7

The procedure described above in Example 6 was repeated using Red Nordland potato tubers. The results of this test are present below in Table 11.

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said thiophanate compound are present in a ratio of from about 3:1:1 to about 1:16:6.

14. A method as recited in claim 13 wherein the plant is a potato plant.

15. A method as recited in claim 13 wherein the fungi is 5 the Late Blight fungus, *Phytophthora infestans*.

16. A method as recited in claim 13 wherein the 2-alkoxyiminoacetamide compound is cymoxanil; and the thiophanate compound is thiophanate-methyl.

17. A method as in claim 13 wherein said fungicidal 10 composition includes a carrier.

18. A method as in claim 13 wherein said fungicidal composition is applied at a rate of from 50 ppm to about 1200 ppm per 100 pounds of seed or tuber.

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19. A method as in claim 13 wherein said fungicidal composition is applied at a rate of from 300 ppm to about 900 ppm per 100 pounds of seed or tuber.

20. A method as in claim 13 wherein said fungicidal composition is applied at a rate of from 300 ppm to about 700 ppm per 100 pounds of seed or tuber.

21. A method as recited in claim 13 wherein said 2-alkoxyiminoacetamide compound is cymoxanil; said alkylene bis-dithiocarbamate complex salt compound is mancozeb; and said thiophanate compound is thiophanate-methyl.

22. A method as in claim 21 wherein said fungicidal composition is applied at a rate of from 300 ppm to about 1200 ppm per 100 pounds of seed or tuber.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,228,883 B1
DATED : May 8, 2001
INVENTOR(S) : Jennifer Lynn Riggs

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 9, claim 1,
Line 28, after "amount of", insert -- a fungicidal --.

Signed and Sealed this

Fifth Day of March, 2002

Attest:

A handwritten signature in black ink, appearing to read "James E. Rogan", written over a horizontal line.

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office